common design concepts for the learning car mechanic

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(fasteners)

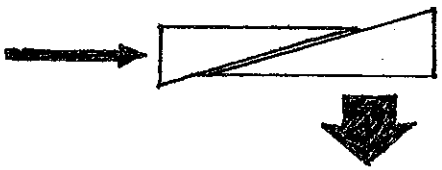
by Magnolia Crescent

The fastener issue!

In this issue I'll try to explain, from the basics up, what's going on when you use a bolt or nut and what to look for when you see one on a car. They're mostly self-explanatory, so I'm going to focus on situations where something could go wrong if you do what looks obvious, or where something has already gone wrong and you're trying to figure out what to do next. Let's talk about kinds of FASTENERS, their HARDNESS GRADES, TORQUE measurements, THREAD REPAIR, and methods of EXTRACTION!

(A lot of this information came from the chapter on fasteners in Tim Gilles's textbook Automotive Service.)

BOLTS and all threaded objects work on the principle of the wedge, AKA inclined plane. In this diagram, you can see how pushing the left wedge to the right a long distance will push the right wedge down a much shorter distance—but with much more force.

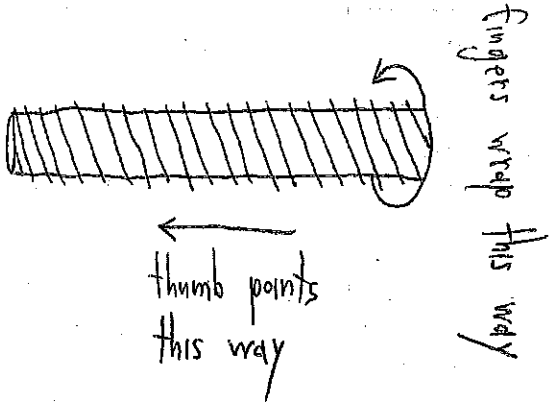


thus...

One example of this is a sash lock on your window: you can see how the moving part is slightly tapered, and how it slides against the stationary part to press the windowpanes apart.

good luck out there!

♡ Magnolia



the right hand rule

If you couldn't save the thread in the hole or put a nut on the other side of it, you'll have to drill the hole bigger and add new threads. If you have the right size tap and drill bit, you can make a threaded hole of the next size up, but then you'll need a bigger bolt, and you'll have to enlarge the hole in whatever the bolt went through. You can also use a special tap and a thread insert to get back to the original size.

When drilling through steel:

Use some motor oil or other thick oil to lubricate the bit, push hard, and go pretty slow. Spinning the bit too fast will heat it up and make it soft and dull. One way to gauge this is go slow enough that you can see the bit turning, and not so fast that it looks like a blur.

It'll go faster if you can use a good sharp bit designed to cut hard metal. Also, be careful not to break a drill bit in the hole, because there's no drill bit that will cut through a drill bit.

Some final advice...

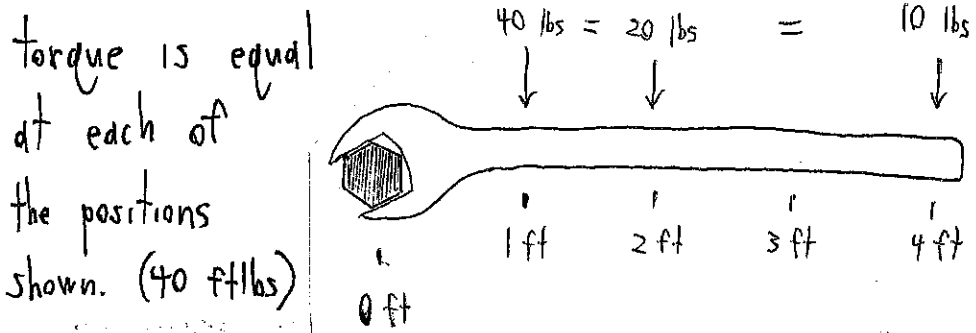
When you encounter an unexpected problem, especially if you caused the problem, it's easy to lose sight of the big picture. It can feel imperative to do something, anything, to get yourself out of the situation, but in those moments, calm thinking has always been more helpful to me than action. I don't know how much time I've wasted trying to break loose a seized bolt only to find out it was the less stuck of TWO bolts holding something on, or drilling out a bolt only to destroy the hole and have to get a whole new bracket anyway, or trying all my less reliable bolt-loosening tricks after the good ones have failed. The good mechanic stays calm and figures out the best plan, and sometimes that's to give up and put it all back together again, at least until you have the right tool.

As they say in a terrible disney movie from my childhood, "it's not a retreat, it's an advance to the rear."

Bolts work just the same way, only the inclined plane spirals all the way around the shaft of the bolt. When you turn the bolt, the thread pulls it into the hole, and anything between the threaded hole and the head of the bolt will be squished between them. Once the head of the bolt hits an unmoving object, any further turning of the head can only happen because the bolt stretches a tiny amount. That's why bolts get harder and harder to turn as you keep going—they're stretching more and more. You might have felt the turning get easier right before a bolt breaks, and what you feel is the bolt being stretched past its yield point (the point after which it can't return to its original shape).

TORQUE is a measure of force.
(this section was also in issue 1 of this zine)
The more you turn a bolt, the tighter it clamps down on anything sandwiched in between the head of the bolt and the hole or nut it threads into. Sometimes the manufacturer needs to tell you how much clamping force to put on something, like a gasket or a ball joint. There's no practical way to measure clamping pressure, though, so instead we measure torque, or the amount of force directed toward turning the head of the bolt. That is, we measure how much "weight" we put on the end of our wrench.

Since the same amount of weight produces more force at the end of a long lever than a short one, we give the measurement in both length and weight: foot-pounds (ftlbs), or newton-meters (Nm) in metric. 20 ftlbs is the amount of torque produced by 20 pounds on the end of a foot-long lever, measured from the center of the bolt. Torque is measured with a torque wrench.

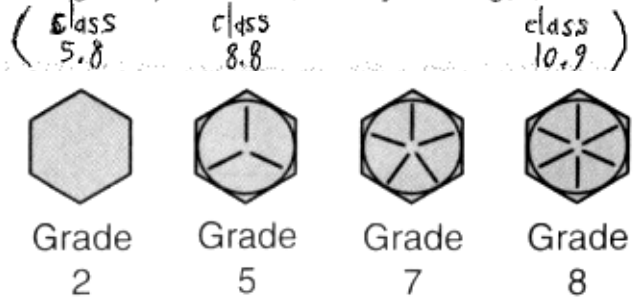


However, torque doesn't translate directly into clamping pressure. The same torque can produce very different clamping pressure based on the angle of the thread of the bolt: finer thread gives more clamping pressure per foot-pound of torque than does coarser thread. Also, since friction between the threads makes a bolt harder to turn, the same amount of torque counts for less clamping pressure if the threads are rusty or dirty, and more if the threads are lubricated. (Torque specs are given for clean, dry thread unless they say otherwise.) Excessive torque twists off the head of a bolt, but excessive clamping force is what pulls the threads out of the hole—so if you go by feel, take into account the thread pitch and lubrication. A torque spec for dry thread can be too high and strip the hole if the thread is lubricated.

Nowadays, manufacturers specify the torque for just about everything, but different mechanics have different opinions about which things actually need to be torqued to spec.

HARDNESS measures how much force you can put on a bolt before it breaks. Most bolts on cars are metric, and the ones you'll encounter most are class 8.8 and class 10.9. The first number tells you how much force the bolt can take without breaking. (The second is its yield strength, but you can ignore that.) Sometimes the number will be on the head of the bolt. Small bolts on the body and in the engine compartment are usually 8.8, and suspension bolts tend to be 10.9. You might also encounter class 5 or 12 bolts (very soft and very hard respectively).

If you run into imperial size bolts, they have their own hardness scale, named in grades, and indicated by markings on the bolt head.



imperial grades with their rough metric equivalents

-if the bolt breaks loose but the threads are so rusty that it gets stuck part way out, use a lot of oil on it and turn it back and forth for a while to work the oil in.
-break it! If it won't leave you minus a special bolt you can't find a replacement for, or with part of a bolt blocking a hole you need, cut it wherever it's exposed. Use an angle grinder, dremel, or bolt cutters. If a nut won't come off a bolt, cut hot dog style down the middle of the bolt all the way through the nut, then chisel the two halves of the nut off.

for broken bolts...

When a bolt breaks off in the hole, you have a few options. If what's left of the bolt is free to move, you can drill a hole in it and take it out with an extractor. Use a pointed punch and a hammer to punch a divot as close to the middle of the bolt shaft as possible, then drill into that divot. When you have a deep enough hole, you can insert an extractor, which usually looks like a tapered spiral, into the hole and use that to twist the bolt out. This is a good method for bolts that broke because you overtightened them. Some people like to use left-handed drill bits for this, which cut counterclockwise instead of clockwise, and can sometimes turn the bolt out without an extractor.

More likely, though, the head broke off because the bolt was seized, and you already applied as much torque as it could stand to no avail. In that case, an extractor probably won't help. You'll have to drill it out. If you're lucky and careful, you can drill away the bolt shank but leave most of the threads there, and then pick them out with a pick. This leaves the threads in the hole relatively intact. Then move on to:

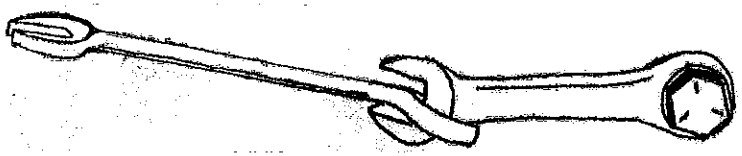
Thread repair! If you had to drill a bolt out of a hole, or if threads are damaged from trying to install a bolt at a bit of an angle ("crossthreaded"), you can often get them usable again with a tap or die. A tap is like a bolt but with a cutting edge to cut thread in a hole; a die is the opposite, it's like a nut and it cuts thread into a rod. If you have a tap of the right size, retapping (AKA "chasing") the hole can make it so a new bolt fits.

-Things with large sealing surfaces, like manifolds, oil pans, and valve covers, shouldn't have all their fasteners tightened one by one, because it can distort the shape of the sealing surface and make it leak. Tighten each a little, then tighten them all a little more, over and over until they're all tight.

PROBLEMS will definitely happen.
Bolts break, bolt holes strip, threads get damaged, and things get very, very stuck together. It happens to everyone. Try not to despair! Take a break and regroup your forces, then try some of the following...

for stuck bolts...

-before you start, hit them with a hammer and then clean them with a wire brush to get rust off
-use penetrating oil or WD-40
-if you're using a 12-point socket, use a 6-point socket instead. If you have more than one 6-point socket of the right size, find the one that fits best.
-if the bolt head is smaller than it started out, because some of it rusted away or got stripped, see if an imperial socket will fit better. 1/2" is between 12mm and 13mm, 3/8" is between 10mm and 9mm.
-if it's not moving at all, use a bigger breaker bar or put a pipe on the end of yours to make it longer. If you have to use a box wrench, you can do this:

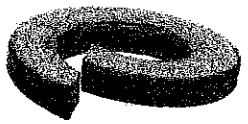


-use an impact driver if you have one
-use a bigger bar AND an impact driver. Stuck axle nuts sometimes come loose this way: use a long impact socket, and while one person uses the impact driver, a friend puts a pipe wrench on the socket with a long pipe on the end and turns it.

This is important! You might not have any problems replacing a class 10.9 suspension bolt with a class 8.8 bolt from the hardware store, but once that bolt sits there for a few years and corrodes, you might have a problem getting it back out without breaking it.

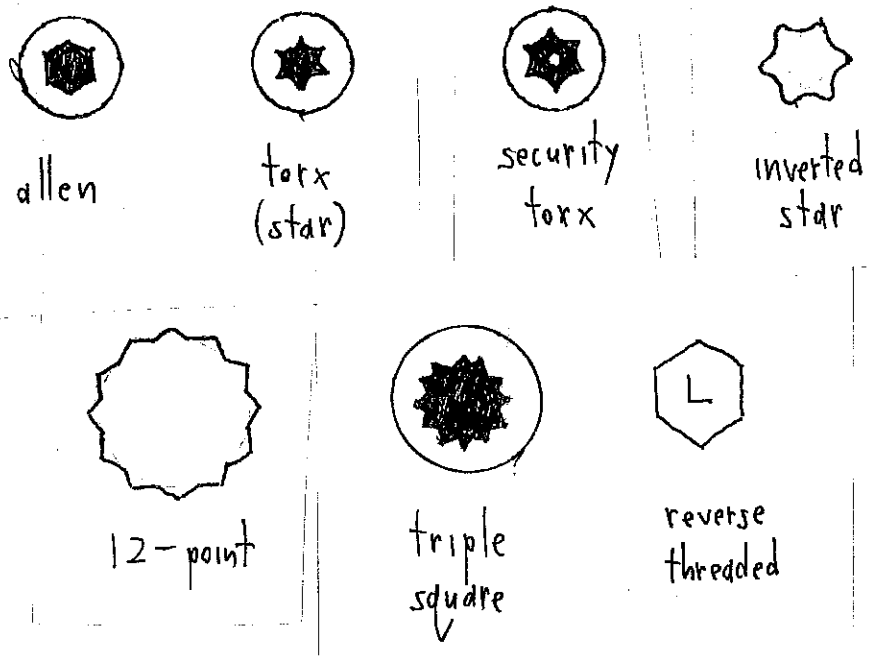
LOCKNUTS are designed with precautions to keep them from coming loose, or to make sure that even if they do come loose, they don't spin themselves off the stud or bolt. There are a few kinds: castle nuts have square slots cut into the top like the battlements of a castle, and they go on a bolt that has a hole in it; you put a cotter pin through the slot and the hole so the nut can't turn. Distorted thread locknuts are squeezed a little in the factory so as to be not quite round, or a little tapered on the inside; they take some hard turning to put on and they tend to destroy the thread of whatever they're on when you take them off. Axles often have staked nuts, which have a thin rim sticking out the top; the axle stub has a groove going down one side of the thread, and you punch the rim into the groove. To remove it, punch the rim back out again with a screwdriver. Some nuts have teeth on the bottom to bite into whatever they tighten onto. Some have a nylon ring in the middle that the threads of the bolt have to cut through.

You can reuse locknuts if you need to, but don't replace them with non-locking nuts. You might come across split lock washers: washers that look like they've been neatly cut in one spot. These are obsolete, and I replace them with a locknut or use threadlocking compound instead.



a split lock washer. don't use this

less common fastener head styles



Sometimes you can get away with using an allen wrench on a star bolt or vice versa, or a regular hex socket on an inverted star.
Studs (threaded rods than nuts go on) often have an inverted star at the end. It's a sign that they're meant to be removed.
Reverse threaded bolts unscrew in the opposite direction and are very rare.

THE RIGHT-HAND RULE is how I know which way to turn things. "Righty-tighty" never made sense to me; I'm turning it in a circle, how can a circle be right or left? Some people say clockwise is tighter and counterclockwise is looser, but if you're behind whatever the bolt threads into, looking from the other side, it's the opposite.

This rule will always work: in your mind's eye, grasp the bolt with your right hand, as if it's the handlebar of a bike. Stick your thumb out like you're giving a thumbs-up, and turn your hand so your thumb points in the direction you want the bolt to move. Your fingers, curling around the bolt, will point the way you need to turn it to get it to move in that direction. It works for nuts too. Try it! If the fastener is reverse threaded, AKA "left-handed," use your left hand instead of your right.

A FEW SITUATIONS IN WHICH YOU SHOULD NOT DO WHAT SEEMS OBVIOUS:

-Steel bolts that go into an aluminum object, like a cylinder head, can get pretty stuck because of galvanic corrosion. It makes sense to use anti-seize lubricant there, but don't torque them to spec if you use it, because they'll probably strip the hole. You can recognize aluminum by its pale color and the white rust-like corrosion often seen on it.

-If a bolt comes loose but then gets harder and harder to turn as it comes out, stop and figure out what's happening. Is there pressure on it? Is the other end sticking out the far side of the hole and completely covered in rust? Sometimes it's better to cut off the rusty end than to get it stuck even worse and destroy the thread of the hole too. Likewise, if a bolt starts to go in fine but gets harder and harder as it goes, make sure it's not crossthreaded. If the thread's rusty, some friction might be fine, but sometimes it's worth cleaning or rethreading the bolt to make sure there's not another problem.

-If a bolt goes into sheet metal too thin to cut threads in, it'll be threaded into a nut welded to the other side of the sheet metal. It's good to notice this, because if the bolt is stuck, the welds can break before the bolt, and then the bolt will spin freely with the nut stuck on the end.